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Trends and Insights in Renewable Energy Selection for Sustainable Development: A Bibliometric Analysis

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Abstract: This study focuses on the critical role of renewable energy selection (RES) in achieving Sustainable Development Goal 7 (SDG 7), which aims to provide universal access to clean energy. Selecting the right renewable energy sources is essential for sustainable development in any region. Through a bibliometric analysis of publications from Scopus and Web of Science, this research examines the techniques used for RES, utilizing the R package 'Bibliometrix.' The study identifies key trends, methods, and advancements in RES, offering valuable insights into the evolving research landscape. It also highlights the top researchers and their global contributions, providing a comprehensive understanding of current progress in renewable energy selection. These findings indicate noteworthy trends and techniques that may enhance energy decision-making, which might be helpful information for academics and policymakers. Nevertheless, the emphasis on Web of Science and Scopus can hide relevant findings from other sources. To achieve more comprehensive knowledge, future studies have to incorporate more databases. This study establishes the foundation for enhancing RES techniques and supporting sustainable energy policy globally, regardless of its limits.

Introduction

Renewable energy sources (RES) are the cleanest sources of energy, which do not pollute or hurt the environment. They are considered a non-exhausted form of energy, which can be replenished over time. They are considered the energy industry's future due to their widespread availability (Güney, 2019). However, their full potential remains untapped due to limited understanding and technological advancements (Rana Virendra Singh and Singh, 2024). In contrast, when burned, non-renewable energy sources, such as fossil fuels, emit significant amounts of greenhouse gases. These gases, like carbon dioxide and methane, trap solar energy, leading to a rise in the Earth's temperature (Mendoza et al., 2023; Xin et al., 2023). Non-renewable sources release pollutants like unburnt hydrocarbons and particulate matter, causing environmental damage (Güney, 2019). Pollution is a global concern, emphasizing the urgent need to reduce reliance on non-renewable energy sources. According to the "Ministry of New and Renewable Energy, Government of India" (November 2023), India's current non-fossil fuel capacity has increased by 396% over the last 8.5 years to more than 179.57 GW, including nuclear and big hydropower, accounting for around 42% of total capacity (Ministry of New and Renewable Energy | Ministry of New and Renewable Energy | India, 2023. In 2022, India demonstrated remarkable progress by achieving a

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significant increase of 9.83% in renewable energy installations, marking a pivotal stride toward sustainable energy development. The installed solar energy capacity has increased 30 times in the past nine years, reaching 74.30 GW in January 2024 (Ministry of Statistics and Program Implementation | Government of India, 2024. However, globally, fossil fuels still dominate the energy landscape, accounting for around 70% of total energy consumption in 2023. This highlights the need to speed up actions to reach the targets of Sustainable Development Goal 7. These targets aim to make sure "everyone has access to energy that is affordable, dependable, sustainable, and up-to-date" (Goals Archive - The Global Goals, 2023). In the field of RES, several strategies have been investigated and published in the literature to aid in informed decision-making processes. For example (Siksnelyte-Butkiene et al., 2020) examine different policies and strategies aimed at enhancing energy efficiency in households, including the adoption of RES, retrofitting of residential structures, and the use of energy-efficient appliances. A bibliometric study related to household energy efficiency was done in this research, consisting of publications of 2010-2023 duration.

Multi-Criteria Decision-Making in Renewable Energy Selection

"Multi-criteria decision-making"/(MCDM) has been widely used in renewable energy research, particularly in prioritizing ranking or finding the most suitable renewable energy. Various forms of MCDM tools have evolved depending on the conditions and factors for the research. Techniques like "Analytic Hierarchy Process (AHP)", "Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)", "Elimination and Choice Translating Reality (ELECTRE)", "VIsekriterijumsko KOmpromisno Rangiranje (VIKOR)" etc (Rana et al., 2024; Rana Virendra Singhand Singh, 2024a) can be found, which are used in this area (Lak Kamari et al., 2020). The various MCDM techniques allow the researchers and stakeholders to rank the renewable sources of energy by using both qualitative and quantitative data (Liu and Rodríguez, 2014). The MCDM techniques can be integrated with fuzzy techniques, which, when used in real-life situations, provide more relevant and useful results (Ebrahimi, 2018; Göçmen-Polat, 2024). The advantage of using fuzzy with MCDM is that they can deal with uncertainty, vagueness, and ambiguity while dealing with a real situation (Kahraman and Tüysüz, 2017a, 2017b). The data, whether linguistically discrete or numeric, can be broken down further, using a fuzzy scale which can be extremely useful for researchers or policymakers to solve decision-making problems (Kahraman and Tüysüz, 2017b, 2017a; Torra, 2010).

Use of Machine Learning and Artificial Intelligence

Recent studies show that "Machine Learning (ML)" and "Artificial Intelligence (AI)" are being used along with the MCDM and fuzzy techniques. This hybrid technique can be used to increase the performance and efficiency of the existing prediction model or can be used to generate a new model for the same type of selection process (Benti et al., 2023; Lai et al., 2020). The "Support Vector Machine (SVM)" is a famous ML technique that is used for prioritizing and forecasting how the renewable energy field works based on the different forms of data (Bostancı et al., 2024; Zendehboudi et al., 2018). "Decision Trees and Random Forest" can also be used to investigate complicated decision-making problems, which gives a view of the various factors that influence the selection of renewable energy sources (Cattani, 2023; Karasu & Altan, 2019). "Artificial Neural Networks (ANNs)", one of the trending approaches in AI, "Convolutional Neural Networks (CNNs)" and "Recurrent Neural Networks (RNNs)", can be used to find the relationship between the extremely complicated renewable energy data (Rahman et al., 2021; Sabri & El Hassouni, 2022). Clustering algorithms such as K-means and hierarchical clustering are used to categorize renewable energy sources based on their unique characteristics and attributes (Jiao et al., 2024; Niu et al., 2021). "Genetic Algorithms (GAs)" and "Particle Swarm optimization (PSO)" are evolutionary computation techniques used to enhance the design, implementation, and operation of renewable energy systems (Mehrizi-Sani et al., 2023; Suresh et al., 2022). They look for optimum solutions throughout a large solution space." Reinforcement Learning (RL)" approaches such as Q-learning and Deep Q Network (DQN) are also being investigated to develop adaptive and self-sufficient renewable energy management and control systems (Alabdullah and Abido, 2022; Shen et al., 2022). Integrating machine learning approaches with traditional decision-making processes results in a synergistic approach.

Renewable Energy and Sustainable Development Goal 7

Renewable energy finds its special position in SDG 7, which targets clean and accessible power for everyone (Goals Archive - The Global Goals, 2023Sustainable criterion selection is a major problem in renewable energy selection because it can easily change due to socioeconomic, geographical, environmental, and cultural

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factors (Büyüközkan et al., 2018a; Sitorus and Brito-Parada, 2022). Significant research has been conducted on renewable energy and related domains. Several scholars have presented models and strategies that can be used to address this issue. MCDM is an important tool for solving decision-making problems (Kabak and Dağdeviren, 2014; Li et al., 2020). It may be used to determine the weight (for example, AHP) and ranking (for example, TOPSIS) of items in the selection process system (Lai et al., 1994; Liberatore, 1982; Saaty, (1977). A Scaling Method for Priorities in Hierarchical Structures Saaty, 1977, the AHP, TOPSIS, and VIKOR methods have all been widely employed in this discipline (Taylan et al., 2020). A study on ranking renewable energies in India using the AHP and Delphi Methods was successfully conducted (Pathak et al., 2022). A similar sort of research was done by Percy and Edwin (2023) to evaluate the criteria and options in the various blocks of the region using AHP. Researchers also incorporate AHP Shannon Entropy into the MOORA evaluation for the renewable energy project (Petrov, 2021). Another study was conducted in Iran by Sedghiyan et al. (2021), who used AHP, TOPSIS, and SAW to determine the best appropriate criterion and renewable energy in five climatic zones. Research also employs AHP to conduct our study on finding smart cities in western India (Bhowmik et al., 2018).

Fuzzy Integration with Multi-Criteria Decision-Making

When the MCDM technique is applied to a real-life scenario, it might result in uncertainty, ambiguity, and confusion (Zadeh, 1965, 1975, 1978, 1999). These can be addressed by combining fuzzy sets with the MCDM approach (Chu and Lin, 2009; Çolak and Kaya, 2017; Djenadic et al., 2022). There are other occasions where these two strategies are combined and employed in the energy selection process. The authors use "Fuzzy-TOPSIS" and demonstrate that ambiguity and uncertainty were effectively addressed when determining the most appropriate renewable energy (Quteishat and Younis, 2023). The authors compare "Fuzzy TOPSIS and Fuzzy PROMETHEE" after rating the renewable energy sources. A study used AHP and Fuzzy TOPSIS to identify the most critical elements in determining the ranking of renewable energy in Pakistan (Wang et al., 2020). Li et al. (2020) successfully employed "interval type-2 fuzzy sets (IT2FSs)" and TOPSIS to identify renewable energy. Decision-making can be more efficient if it occurs in a hesitant atmosphere in which the decision-maker is hesitant to express his or her views. Some of the researchers have explored the "Hesitant Fuzzy Linguistic set" together with "AHP and COPRAS," working on numerous criteria and sub-criteria while achieving the "Sustainable Development Goals" (Büyüközkan et al., 2018b, 2020; Büyüközkan and Güleryüz, 2017). A study introduced a novel fuzzy aggregation operator for consolidating evaluations from decision-makers, employing fuzzy weights instead of crisp ones (Deveci et al., 2020). To show how well the modified CODAS method works, the authors present a case study involving the selection of renewable energy options in Turkey based on multiple criteria. They compare this method with two other CODAS methods found in previous studies that also use interval-valued intuitionistic fuzzy logic. "Type-2 fuzzy sets and Hesitant fuzzy TOPSIS" were also applied to figure out how important each criterion is in finding suitable renewable energy options, and then they checked how sensitive the results are to changes in those criteria (Çolak and Kaya, 2017).

Proposed Research

The study here focussed on performing the bibliographic analysis of the publication related to the renewable energy selection indexed in Scopus and Web of Science databases. Bibliometrics is gaining popularity in research as it examines research and development of science quantitatively and qualitatively (Ejaz et al., 2022a). To do so, the quantitative approach is used to conduct the bibliographic analysis. The current study uses “Bibliometrics”, an R program with a web-based interface called “Biblioshiny”, for bibliometric analysis. As per the databases, this study is the first bibliometric study to evaluate renewable energy trends and insights for sustainable development research. For example, a recent study on the bibliographic analysis was carried out by Siksnelyte-Butkiene et al. (2020), who examined different policies and strategies aimed at enhancing energy efficiency in households, including the adoption of renewable energy sources, retrofitting of residential structures, and the use of energy-efficient appliances. The study in this research identifies the various techniques used for the selection or prioritization of renewable energy, which can inform local and worldwide research programs. Visualization data may be used to analyze past research output on a subject and suggest future research opportunities and collaborations.

The remainder of this study is organized as follows: Section 2 outlines the methodology for conducting the bibliometric analysis and details the approach used to gather and analyze data. In section three, the results are presented and discussed using graphs and visualizations to illustrate key trends and insights. Finally, section four

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provides a thorough conclusion, summarizing the main findings. This section also discusses the study's limitations and offers suggestions for future research.

Research Methodology

This study follows the literature review methodology suggested by Rowley and Slack (2004), which is widely used by researchers in various fields, as shown in papers by Mahadevan and Joshi (2022), Mourão and Pinto (2017), Punjani et al. (2019) and Sood et al. (2024). We followed a step-by-step approach to assess research papers on renewable energy selection techniques. The methodology starts with identifying and selecting the database for the literature search, followed by describing the search syntax, filters, and bibliometric tool used to conduct the study, as shown in Figure 1.

Identification and selection of the database for literature search

To start with the bibliometric analysis, the author identifies the important and well-known databases for conducting the bibliometric analysis of the research works in renewable energy selection techniques. “Scopus” and “Web of Science-Core Collection (WoS)” databases are the two most widely used resources for academic research and review, allowing researchers to extract the broad coverage of literature across all disciplines. Both databases collect top-notch literature from trustworthy and reputed publishers, ensuring one to access credible information. They allow one to conduct bibliometric-based studies by allowing data export to various analytical tools, facilitating trend analysis,

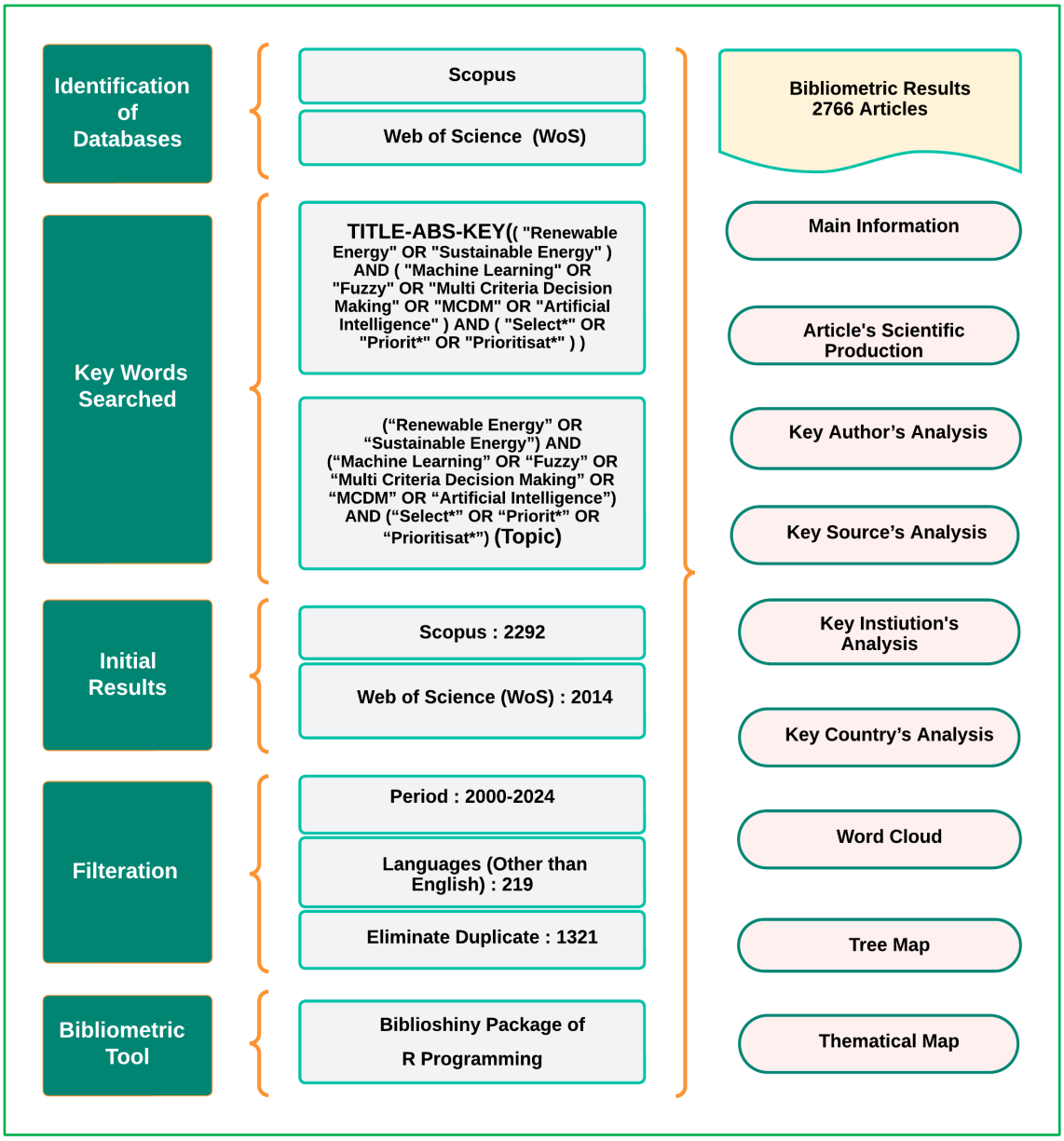
Identification of Databases
Scopus
Web of Science (WoS)
Key Words Searched
TITLE-ABS-KEY(("Renewable Energy" OR "Sustainable Energy") AND ("Machine Learning" OR "Fuzzy" OR "Multi Criteria Decision Making" OR "MCDM" OR "Artificial Intelligence") AND ("Select*" OR "Priorit*" OR "Prioritisat*"))
(“Renewable Energy” OR “Sustainable Energy”) AND (“Machine Learning” OR “Fuzzy” OR “Multi Criteria Decision Making” OR “MCDM” OR “Artificial Intelligence”) AND (“Select*” OR “Priorit*” OR “Prioritisat*”) (Topic)
Initial Results
Scopus : 2292
Web of Science (WoS) : 2014
Filteration
Period : 2000-2024
Languages (Other than English) : 219
Eliminate Duplicate : 1321
Bibliometric Tool
Biblioshiny Package of R Programming
Bibliometric Results 2766 Articles
Main Information
Article's Scientific Production
Key Author’s Analysis
Key Source’s Analysis
Key Instiution's Analysis
Key Country’s Analysis
Word Cloud
Tree Map
Thematical Map

Figure 1. Research Methodology Adopted for Bibliometric Analysis.

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citation tracking, and collaboration assessment within specific research domains. The advanced search feature of both databases permits researchers to proficiently filter pertinent research based on criteria like keywords, authors, publication dates, areas, etc. Additionally, publishing in journals/books/proceedings indexed in Scopus/WoS increases academic value, strengthening the visibility and impact of researchers' contributions in the academic field (Falagas et al., 2008).

2.2 Search Syntax

Identifying the keywords for the literature search is crucial in conducting a review to ensure a broad search. The authors have gone into the well-cited articles published in the domain of selection of renewable energy, identified the keywords mentioned, and prepared a comprehensive keyword list that enables an integrated search (as depicted in Table 1), covering all relevant literature. The search for research literature employed a keyword string that involved terms such as ("Renewable Energy" OR "Sustainable Energy" and Machine Learning" OR "Fuzzy" OR "Multi-Criteria Decision Making" OR "MCDM" OR "Artificial Intelligence" and ("Select*" OR "Priorit*" OR "Prioritisat*" ensuring coverage of all relevant article in the area. The search period spanned from 2000 to 2024, and the search query was performed on February 28, 2024.

Table 1. Search Keywords Used in Scopus and Web of Science.

Database	Search Syntax
Scopus (https://www.scopus.com)	TITLE-ABS-KEY(("Renewable Energy" OR "Sustainable Energy") AND ("Machine Learning" OR "Fuzzy" OR "Multi Criteria Decision Making" OR "MCDM" OR "Artificial Intelligence") AND ("Select*" OR "Priorit*" OR "Prioritisat*"))
WoS (https://www.webofscience.com)	("Renewable Energy" OR "Sustainable Energy") AND ("Machine Learning" OR "Fuzzy" OR "Multi Criteria Decision Making" OR "MCDM" OR "Artificial Intelligence") AND ("Select*" OR "Priorit*" OR "Prioritisat*") (Topic)

Initial results of the literature search

The search process began in the Scopus databases with the search string TITLE-ABS-KEY(("Renewable Energy" OR "Sustainable Energy") AND ("Machine Learning" OR "Fuzzy" OR "Multi Criteria Decision Making" OR "MCDM" OR "Artificial Intelligence") AND ("Select*" OR "Priorit*" OR "Prioritisat*")), yielding 2292 articles. Similarly, the same query was conducted in the Web of Science database, resulting in 2014 articles. To extract significant articles, the search queries for both databases were conducted for the word that appears in the title OR keyword OR abstract.

Application of filters

To refine the literature for in-depth analysis, the initial dataset underwent several filters. Initially, to study the growth of various techniques used in the literature for the selection of renewable energy, articles from the year 2000 were included. The first filter was applied in the extraction phase, where the authors retained the literature from the English language only. After applying the filter for the English language only, a total of 2151 research articles from Scopus and 1936 from WoS were selected respectively. The datasets from both databases were then screened for duplicates using the *mergeDbSources()* command in the R software, revealing that 1321 papers from WoS already exist in the Scopus database. After removing the duplicates, the cleaned dataset comprises 2766 research articles from Scopus & Wos.

Bibliometric tool

Various tools are available in the literature to conduct the bibliometric analysis, like biblishiny() of R, VOS viewer, Citespace, etc. The authors utilized the R-studio bibliometric package '*Biblioshiny*' to conduct a broad bibliometric analysis. R, an open-source programming language, forms the backbone of Biblioshiny's functionalities. Aria and Cuccurullo (2017) made the foundation for this approach through their seminal work, which has become popular for conducting bibliometric analysis in the field. As per Aria and Cuccurullo (2017), the authors followed the three key steps for conducting a thorough analysis. Firstly, the data gathering phase is incorporated for data retrieval, loading, conversion, and cleaning to ensure the integrity and quality of the dataset. Afterward, the second step involved rigorous data analysis, including both descriptive and citation analyses, to study the underlying patterns and trends that exist in the literature. Further, the authors conduct the data visualization step to provide insights into various parameters and graphical representations. The data visualization step includes conceptual maps, keyword clusters, co-occurrence networks, histography networks, and country-based affiliation networks. Before moving into these stages, careful devotion was paid to specifying the search syntax, finding the highly cited article, refining results, and accumulating preliminary data.

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Results and Discussions

The R programming package "Biblioshiny" is used to carry out this current bibliometric research results and conclusions. A thorough review of the research environment in various domains was carried out using bibliometric analysis, which provides important trends, writers, journals, and networks of collaboration in graphical form. Insights into the most often referenced and cited research article and the future research domain in the field of "fuzzy-MCDM, machine learning, and Sustainable Development Goal" in the area of renewable energy selection were obtained from the analysis. These outcomes contribute to mapping the knowledge in this multidisciplinary research area and provide the scope for future investigation. Some of the important graphs and images revealing important information about renewable energy selection are explained in this section.

Overview

This section includes the main information, annual scientific production, average citations per year, and three field plots or Sanky's plots regarding the renewable energy selection aligning with the search syntax used in the two databases. Figure 2 shows the main bibliometric information for the "*Renewable Energy Selection Techniques*" obtained using the "Biblioshiny program". A total of 2766 papers were acquired from 1042 sources between 2000 and 2024. The total number of authors who published the related articles is 6748, and 117 documents were single-authored. The average citation per document is 23.23.

Figure 2. Main information of the Bibliometric Analysis.

The yearly scientific output curve, as shown in Figure 3, shows that the number of articles published on "Renewable Energy Selection Techniques" was extremely less till 2006. After that, a continuous rise in the number of articles published can be seen, giving a maximum of 523 in 2022, as shown in Table 2. The published articles in 2023 were 511 as compared to 1 in 2000, which shows the gain of popularity of the research in "*Renewable Energy Selection Techniques*" over the chosen duration.

The average citation per year was the maximum for 2004, as visible from Table 2. The mean total citation per article was the maximum for 2024 (N=444.67), although the number of articles published during this period was very low (N=3), as shown in Table 2. No articles were published between 2001 and 2002; therefore, data for these two periods are not shown.

A visual representation of the connections between the top 10 countries, authors, and the author's keywords is depicted in a Sankey plot, which divides data into three fields (Lupton & Allwood, 2017). These fields can be customized based on the researchers' objectives, such as authors, affiliations, nations, keywords, and more. In this study, the authors were positioned in the middle field, with nations on the left and keywords on the right. Different colored rectangles are used to represent the data, with the height of each rectangle indicating the strength of relationships starting from keywords, authors, or references. Figure 4 illustrates key information about the top 10 productive nations and authors in renewable energy research, highlighting their significant contributions. Notably, research topics related to renewable energy are predominantly authored by individuals from China, Turkey, the USA, and Canada. The Sankey diagram visually represents the distribution of data for countries, authors, and keywords, with thicker

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connections indicating higher information flow between values.

period. Figure 5 shows the top 10 relevant sources that have published research articles about renewable energy

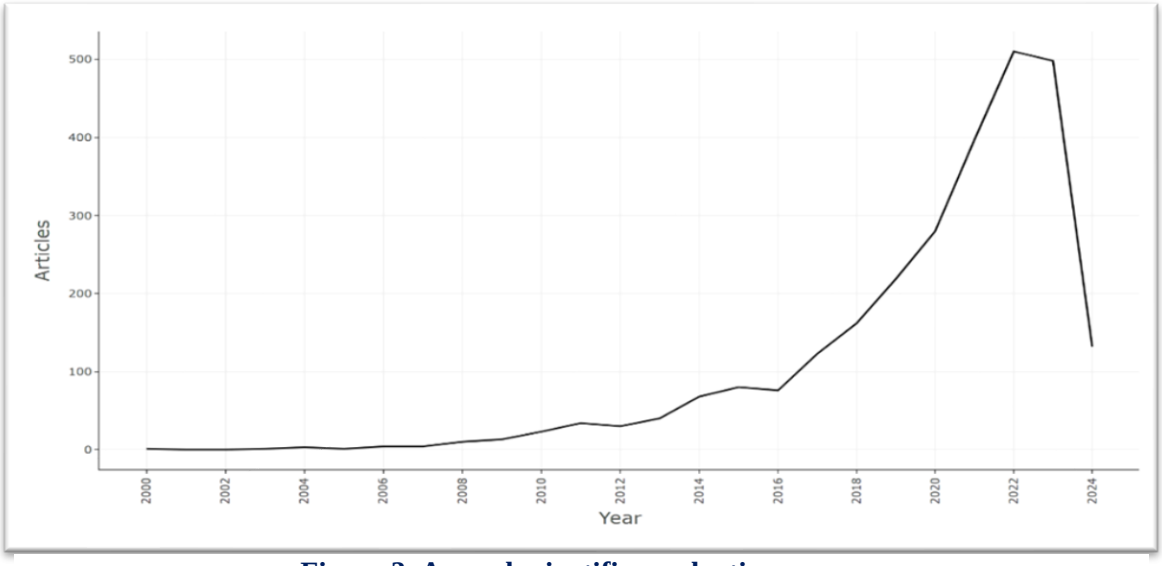

Figure 3. Annual scientific production curve.

Table 2. Mean Citation and Number of Articles Published.

Year	Mean Citations Per Article	Number of Articles Published	Mean Citation Per Year	Citable Year
2000	31	1	1.24	25
2003	8	1	0.36	22
2004	444.67	3	21.17	21
2005	5	1	0.25	20
2006	15	4	0.79	19
2007	46.75	4	2.6	18
2008	20.2	10	1.19	17
2009	154	13	9.62	16
2010	57.35	23	3.82	15
2011	38.71	35	2.77	14
2012	47.97	30	3.69	13
2013	49.98	42	4.16	12
2014	39.38	69	3.58	11
2015	39.44	82	3.94	10
2016	63.69	77	7.08	9
2017	46.8	125	5.85	8
2018	38.01	167	5.43	7
2019	34.68	220	5.78	6
2020	30.12	285	6.02	5
2021	17.72	407	4.43	4
2022	8.51	523	2.84	3
2023	2.44	511	1.22	2
2024	15.37	133	15.37	1

Sources

This section deals with the most research article publishing sources, finding the core area of the research, the H-index or local impact factors of the different sources, and various sources published over the chosen selection. It is found that the "Energies" Journal has published the maximum number of research articles, which is 139. This is followed by "sustainability (97)", "Renewable Energy (92)" and "Energy (89)".

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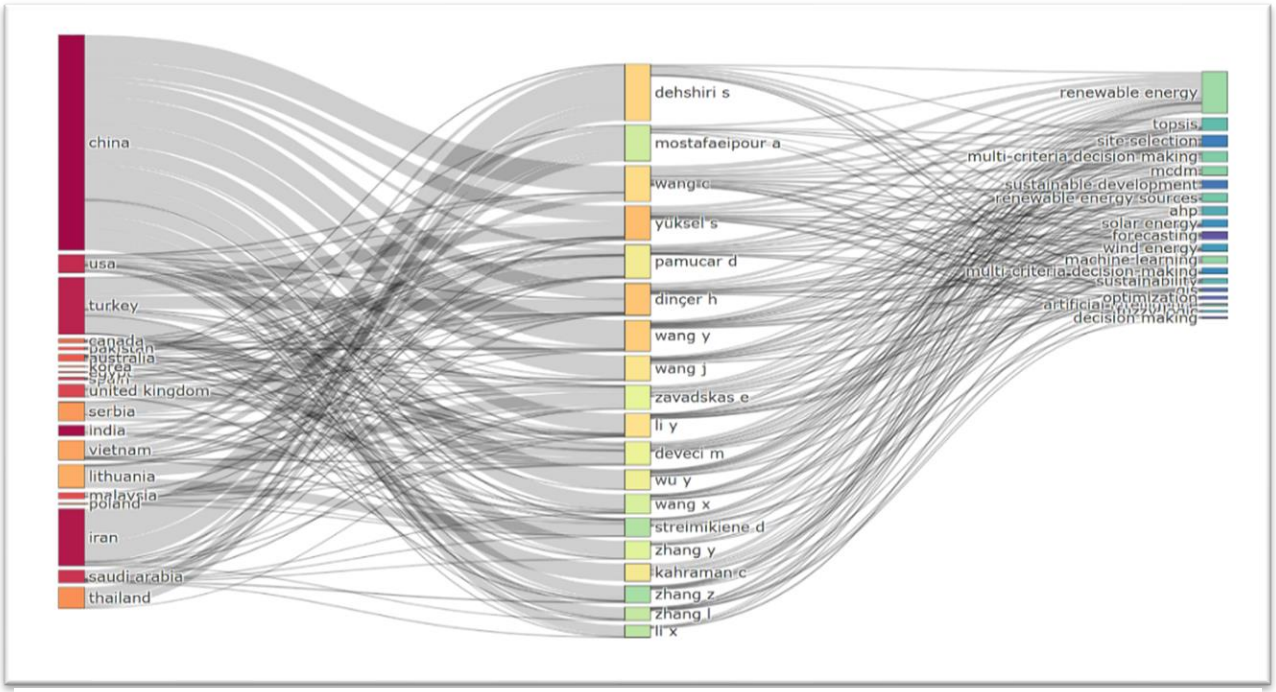

Figure 4. Three Field Plot Showing the Relationship Between Keywords, Authors and Countries.

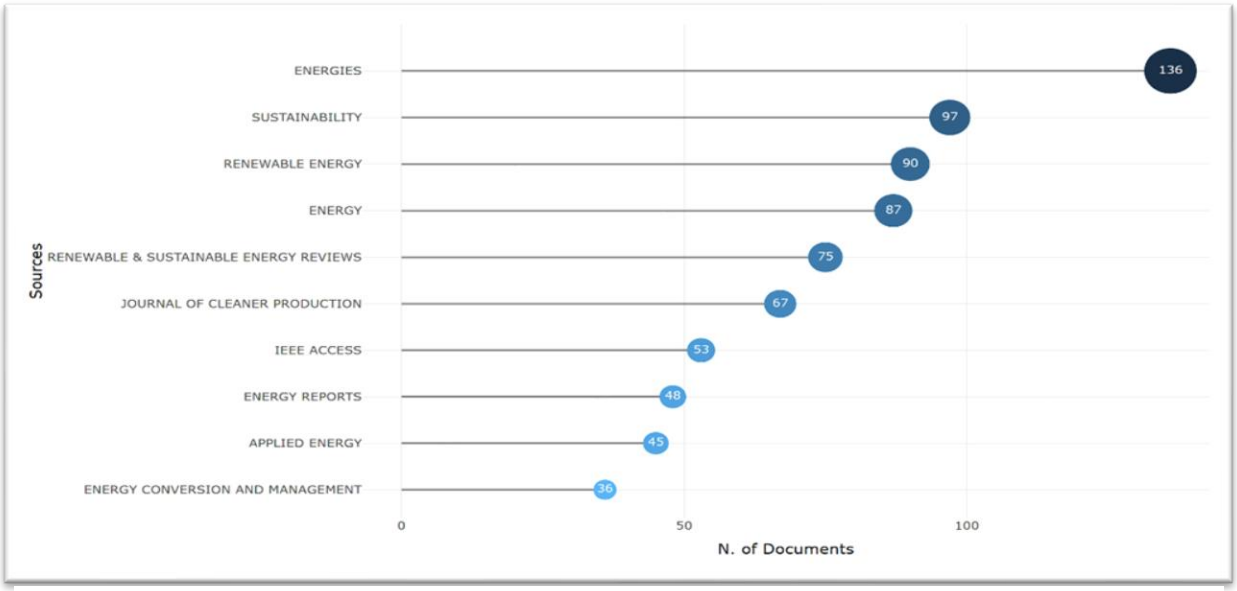

Figure 5. Top 10 Resources Publishing Renewable Energy Selection Articles.

Similarly, the H index of the various sources is found. The H index of "Renewable and Sustainable Energy Reviews (H index = 49)" is the highest, followed by "Energy (H index = 40)" and "Renewable Energy (H index = 39)" respectively.

In Figure 6, Bradford's curve illustrates how articles on renewable energy systems (RES) techniques are distributed across core sources. Bradford's Law, often used in bibliographic studies, explains that a small number of journals or sources usually publish the majority of articles on a specific topic (Brookes, 1977; Solar Revolution, n.d.). This is followed by a larger number of journals with fewer articles each, and then an even larger number of journals with very few articles. Understanding this principle helps researchers grasp how relevant literature is spread out among different sources.

From Figure 6 and Table 3, the sources publishing articles in RES techniques like sources, energies, sustainability, renewable energy, energy, and renewable and sustainable energy review come in zone-1 as shown in the shaded portion (core sources) in Bradford's curve. A total of 16 (top ten are shown here) sources come under the zone 1 category. 181 sources come in the zone-

2 category and 612 sources fall in zone-3 (not shown here).

Table 3. Top 10 zone -1 Sources of Publications

Sl. No	Sources	Rank	Frequency	Cumulative Frequency	Zone
1	Energies	1	139	139	Zone 1
2	Sustainability	2	97	236	Zone 1
3	Renewable Energy	3	92	328	Zone 1
4	Energy	4	89	417	Zone 1
5	Renewable & Sustainable Energy Reviews	5	75	492	Zone 1
6	Journal of Cleaner Production	6	68	560	Zone 1
7	IEEE Access	7	54	614	Zone 1
8	Energy Reports	8	49	663	Zone 1
9	Applied Energy	9	46	709	Zone 1
10	Energy Conversion and Management	10	37	746	Zone 1

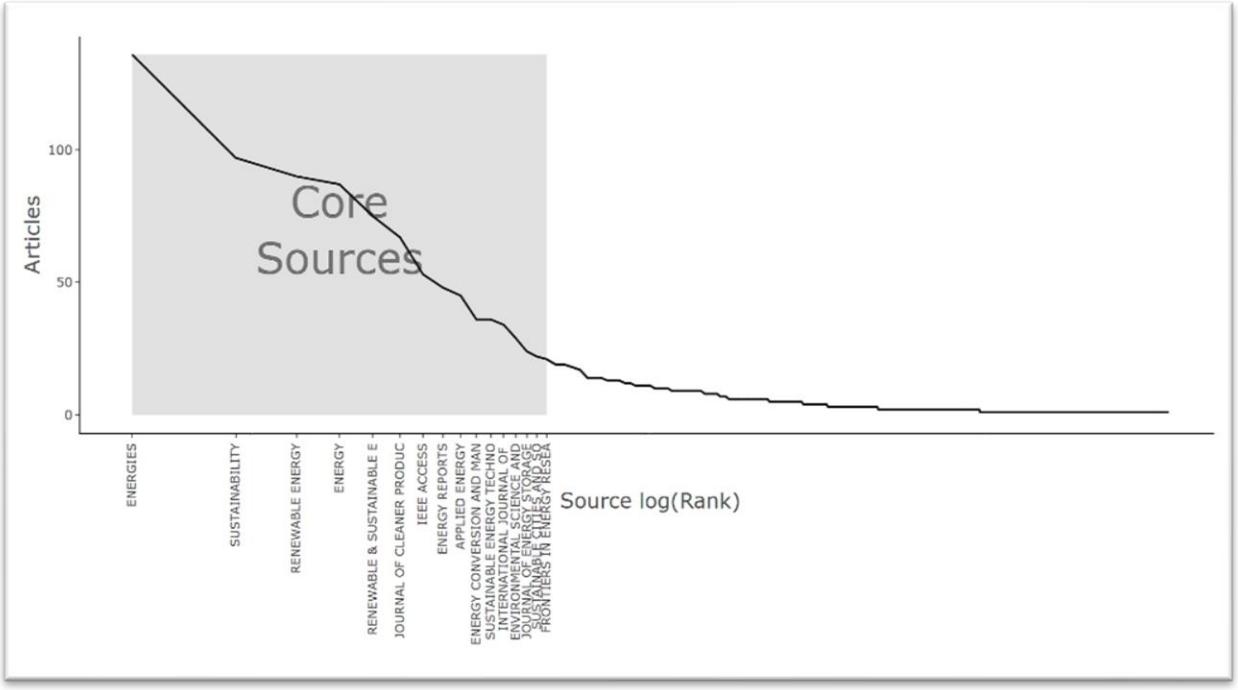

Figure 6. Core sources in RES Research.

The top journals that have published the highest number of articles on RES have formed a source growth plot by the year, as shown in Figure 7. The number of publications by year is listed on the left, and the developments for each year are listed on the right. The increase in RES articles for each publication was essentially nonexistent until 2006, at which point it began to rise slowly before continuing to rise significantly starting in 2008. For instance, the Energies Journal published 137 articles on RES in 2023 compared to 0 in 2001. The most locally cited sources related to RES were "Renewable & Sustainable Energy Reviews (N=49)", "Energy" (N=40), "Renewable Energy" (N=38), and "Journal of Cleaner Production" (N=33).

Authors

This part examines the outcomes of the authors' research analysis on RES, including the most relevant authors, the production of top writers over time, the most relevant affiliations, affiliation production over time, and the country of the corresponding author. The record of the top 10 authors shows that a large number of articles have been found with a lack of information, which is 50, whereas authors, YÜKSEL S, DINÇER H, and Wang Y have published 47, 44, and 36 articles respectively. Figure 8 shows the productivity of top writers over time; for instance, the circles were larger and darker in 2022

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due to Dehshiri S' higher number of articles and citations than in previous years. In 2022, Dehshiri S' published more than four times and received 20.53 citations annually on average.

"Wang C" and "Zavadskas E" both having an H index of 18.

The authors researched RES were mainly from the North China Electric Power University (number of

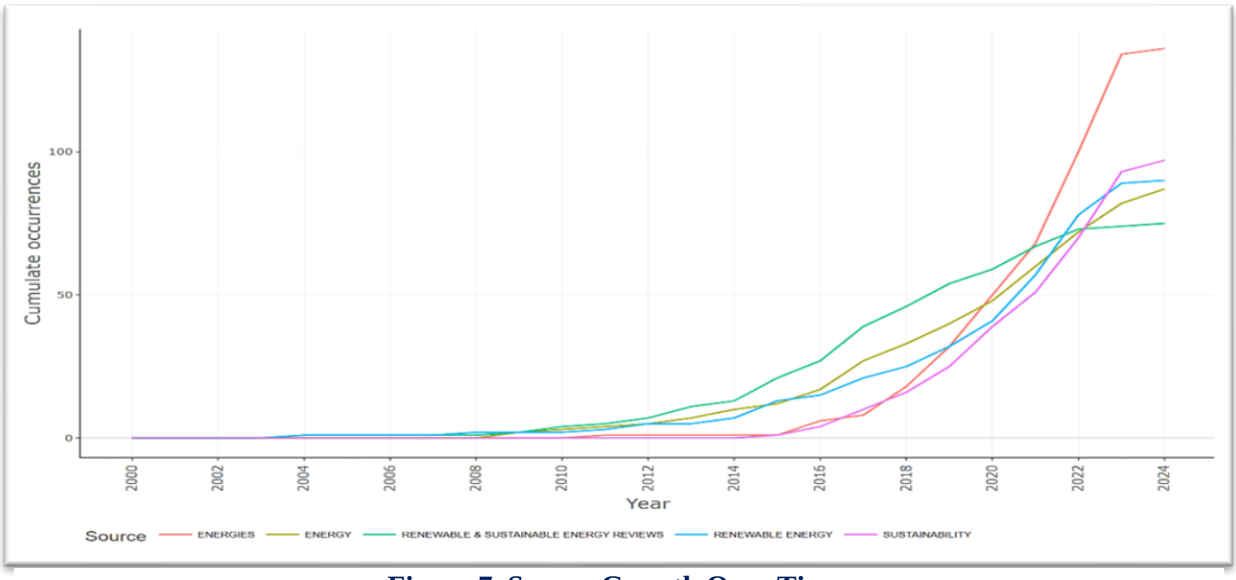

Figure 7. Source Growth Over Time.

The researchers can better understand how many articles each author publishes by using Lotka's law. It explains how scientific productivity is dispersed, signifying that only a few writers published a significant number of articles, as shown in Table 4. The number of authors and their publications increases with the number of scholars who join the particular research area. This pattern establishes that although many scholars may occasionally publish, the majority of scientific production is done by a few highly productive authors.

articles = 82), Egyptian Knowledge Bank (number of articles = 59), Islamic Azad University (number of articles = 55), Istanbul Medipol University (number of articles = 40) and University of Tehran (number of articles = 39). It is also observed from the affiliation's production curve that there is a prominent gain in the curves for all the affiliations doing research in the RES area over the period.

The corresponding authors play an important role in global research collaborations during the bibliographic

Table 4. Scientific Productivity Distribution.

Documents written	Number of Authors	Frequency
1	5255	0.77874926
2	844	0.1250741
3	279	0.04134558
4	142	0.02104327
5	58	0.00859514
6	49	0.00726141
7	26	0.00385299
8	15	0.00222288
9	11	0.00163011
10	14	0.00207469

The H-index helps us visualize an author's impact by showing the number of publications and their citations for the specific research. A higher H-index highlights that an author has several highly cited papers, reflecting their influence in the field. Figure 9 shows that author "Dehshiri S" has a maximum H index of 19, followed by

analysis. The corresponding authors' nations for the various numbers of publications are listed in Figure 10. The corresponding writers were mostly from China (516 articles), followed by India (278), Turkey (188), Iran (185), and the USA (84). The number, ratio, and frequency of RES-related publications broken down by

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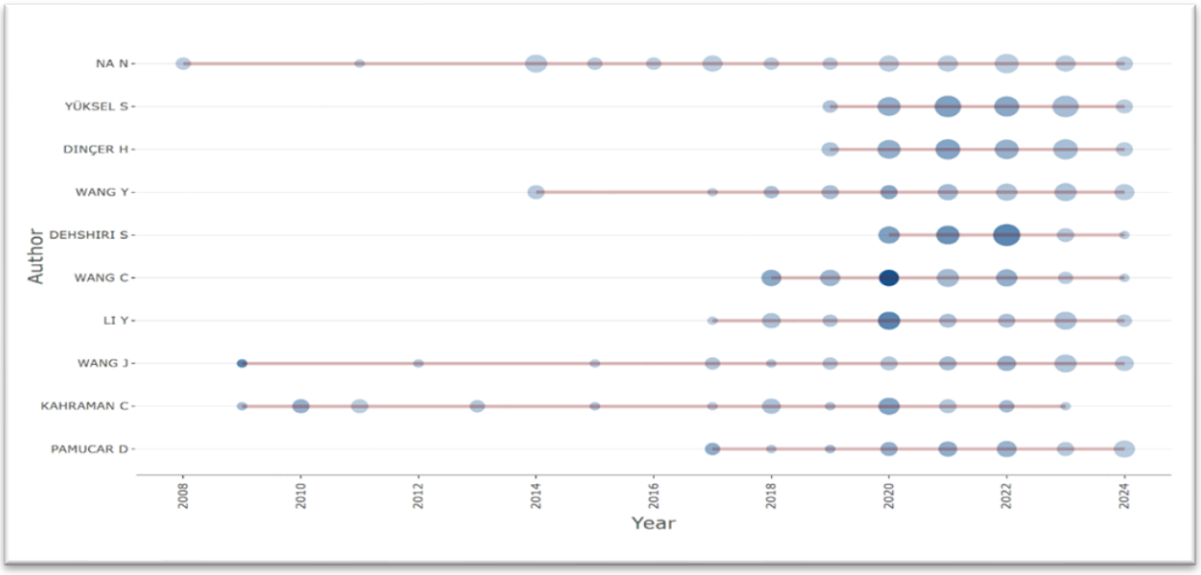

Figure 8. Author's Production Over Time.

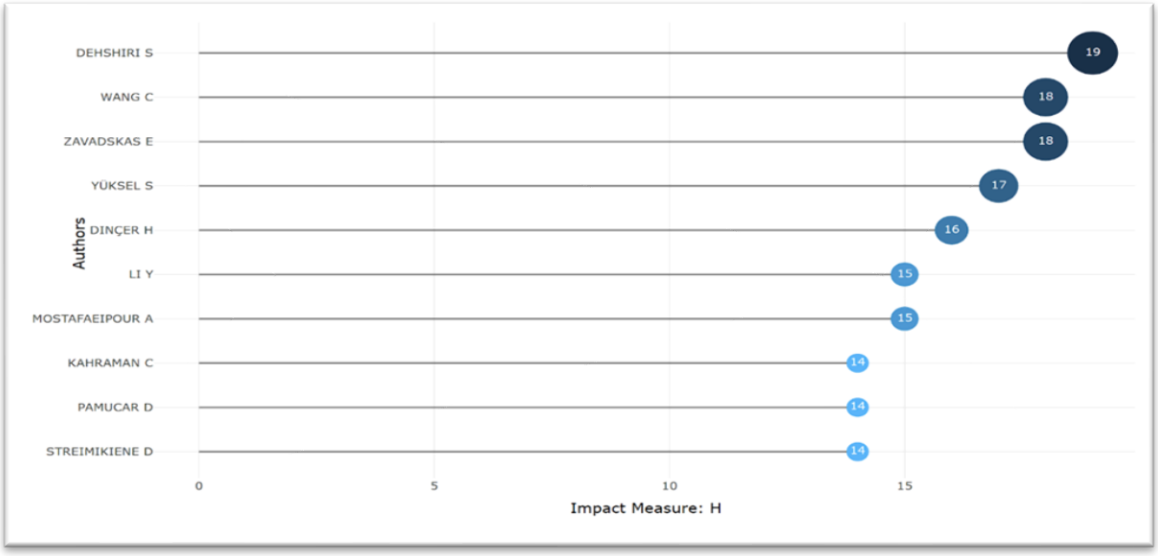

Figure 9. Local Impact Factor of Authors in Renewable Energy Selection Research.

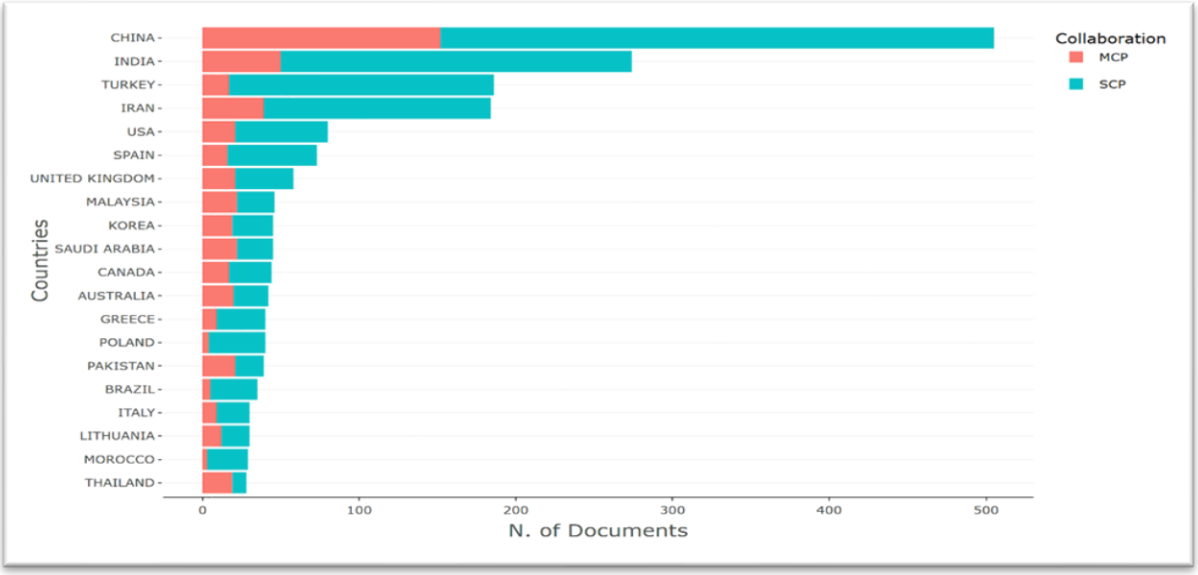

Figure 10. Corresponding Author's country in RES research.

nation, as well as whether they are single-country (MCP), are shown in Table 5. publications (SCP) or multiple-country publications

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Based on the analysis of the corresponding author's nation, China came in first place with 152 articles (f = 0.186). Table 5 demonstrates that, although 152 research studies were carried out in cooperation with writers from other nations, the majority of authors (N = 364) published their publications in China. China had over eight times as many articles on RES as the United States, which is in fifth place. The visual depiction highlights the noteworthy contributions made by corresponding authors from various countries in promoting international research collaborations and propelling the field of renewable energy. The differences between MCP and SCP highlight the joint actions and scope of global cooperation in this field.

Documents

This section displays the major global and local cited references, most frequently used terms, reference spectroscopy, treemap, word dynamics, and trend subjects. The number of times a document is cited globally is used in global citation analysis to identify the document's overall effect. This helps find initial publications that have a major impact on the research subject. The local citation analysis focuses on citations within a specific dataset or research community and offers insights regarding the document's suitability within context. The global citation of some of the papers is shown in Figure 12. It is found that the maximum number of citations are done to Holes S (year, 2024, citation = 2023), in the research area which is included in this bibliographic study. The citation is followed by Wang J (2009, 1386), Kaya T (2010, 159), Phekar SD (2004, 1199), and Kumar A (2017, 857). The most locally cited references are found in the order: Zadeh LA (1965) (N=291), Wang JJ (2009, N=165), Kaya T (2010,

Table 5. Top Ten Corresponding Authors' Countries.

Country	Number of Articles	SCP	MCP	Frequency	MCP Ratio
China	516	364	152	0.18655098	0.29457364
India	278	228	50	0.10050615	0.17985612
Turkey	188	171	17	0.06796819	0.09042553
Iran	185	146	39	0.06688359	0.21081081
USA	84	63	21	0.03036876	0.25
Spain	74	58	16	0.02675343	0.21621622
United Kingdom	59	38	21	0.02133044	0.3559322
Malaysia	48	26	22	0.01735358	0.45833333
Canada	46	29	17	0.01663051	0.36956522

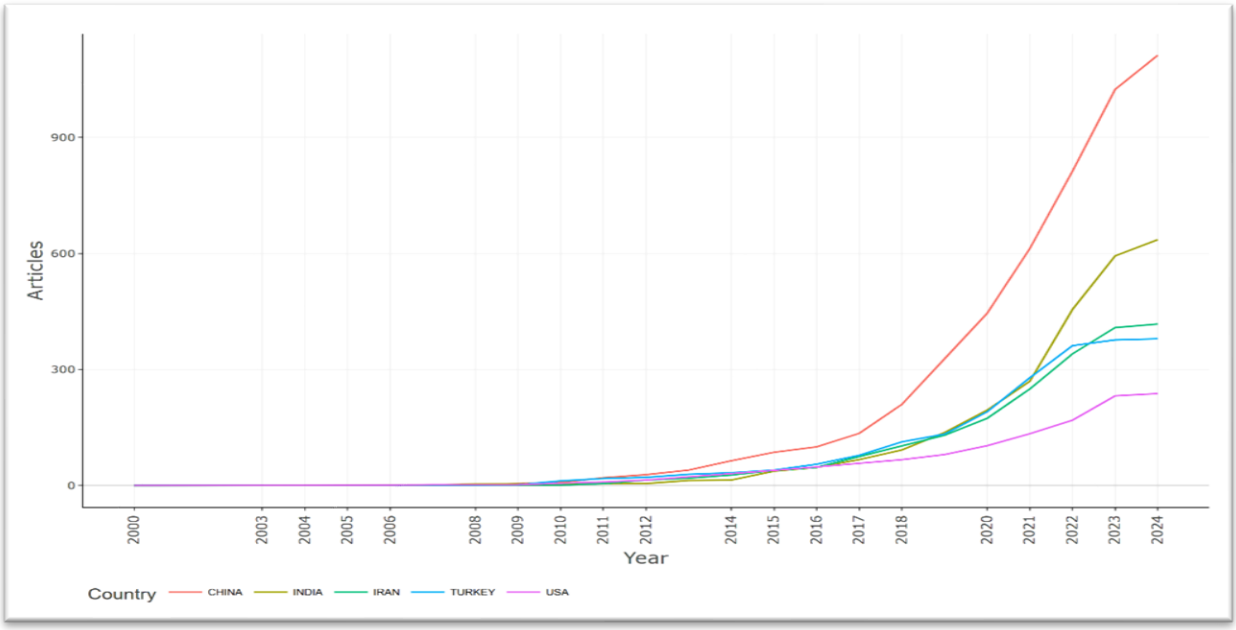

Figure 11. Countries' Production of Articles Over Time.

The country's production of the related research for the period 2000-2024 is shown in Figure 11. The highest and most consistent growth can be seen in China during the chosen time interval. India's recent performance keeps it ahead of countries like Iran, Turkey, and the USA.

N=159), Kumar A (2017, 147), and Phekar SD (2004, 143).

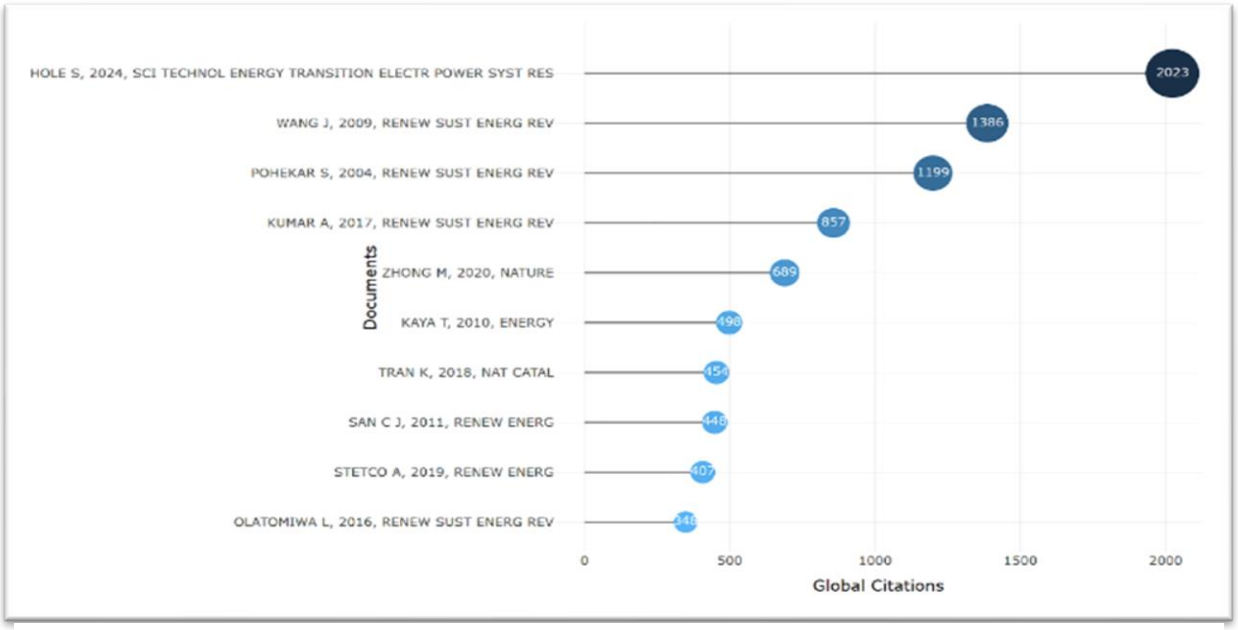

Figure 12. Global Citation of the Documents Related to the Renewable Energy Selection Study

Table 6. Most Frequent Keywords Used in Renewable Energy Selection Research.

	Keywords									
Year	**Selection**	**Renewable Energy**	**Model**	**Optimization**	**Decision**	**Renewable Energy Resources**	**Systems**	**MCDM**	**Site Selection**	**System**
2005	1	1	1	2	1	2	0	0	0	1
2006	1	1	1	2	1	2	0	0	0	1
2007	2	1	2	2	4	5	0	1	0	2
2008	2	1	3	3	5	10	0	1	0	2
2009	4	3	4	6	9	12	0	3	0	4
2010	7	3	5	6	14	19	2	4	0	5
2011	10	3	7	9	23	25	2	4	0	6
2012	13	4	9	15	29	29	4	4	3	8
2013	17	8	14	20	32	34	6	6	5	10
2014	26	16	17	21	41	42	7	7	7	14
2015	41	28	26	25	48	51	15	13	10	21
2016	52	40	33	38	62	59	22	17	15	26
2017	79	63	54	52	73	72	31	30	24	36
2018	102	85	81	66	90	82	42	41	31	45
2019	127	117	102	88	99	98	58	59	46	57
2020	178	155	133	110	126	111	88	78	69	72
2021	229	208	191	146	155	134	125	104	100	93
2022	298	271	251	193	178	159	155	140	137	133
2023	352	317	298	241	206	199	180	170	163	164
2024	365	334	312	249	214	201	186	179	175	174

Table 6 shows the most relevant words used in our research area for the duration 2000-2024. It was found that the keyword "Selection" was used maximum time (frequency = 365, 6%), followed by renewable energy (f=334, 5%), model (f=312, 5%), and optimization (f=249, 4%).

A visual representation of the keywords that appear most in the literature on renewable energy selection can be seen from the word cloud from our bibliographic analysis. The important keywords for this research study

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are "renewable energy," "selection," "optimization," and "multicriteria decision-making". Larger words appear more frequently in the studied documents; the size of each word indicates the frequency, as shown in Figure 13. Concerning the research study of renewable energy selection, this visualization helps to identify the important themes and concepts by emphasizing priority areas and emerging trends. To consider sustainable development, fuzzy logic, and machine learning decisions for renewable energy systems, it is important to incorporate these concepts into the research.

multiple topics. This offers a thorough overview of the area and helps researchers learn key themes, emerging trends, and potential gaps in the literature.

A bibliometric network visualization for choosing renewable energy sources is shown in Figure 15. "Renewable energy selection" is the main node, with the other nodes reflecting important terms and concepts, that are interconnected. Important keywords like "multicriteria decision-making," "analytic hierarchy process," "optimization," and "site selection" surround it, signifying its applicability in the field of study. The

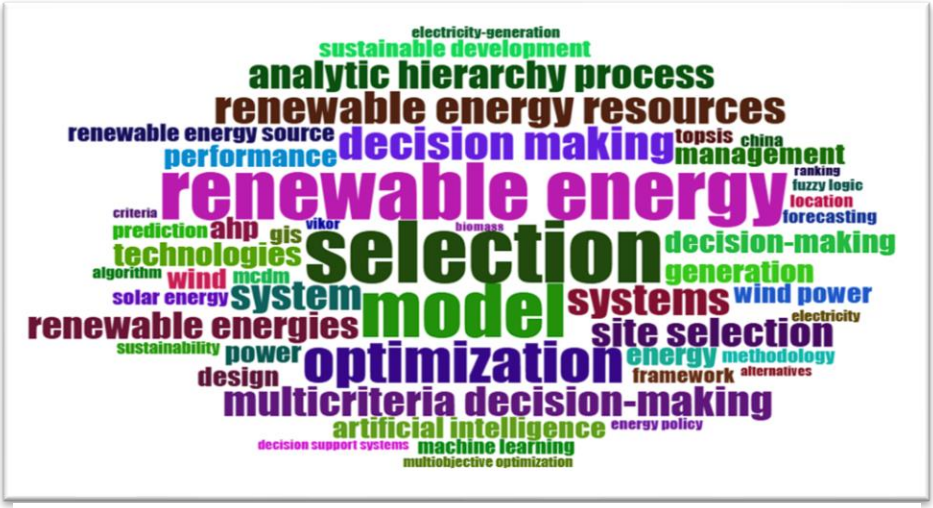

Figure 13. Word Cloud Representing Most Frequent Research Words.

In the context of our research study, that is renewable energy selection, "machine learning" is the most popular topic according to our bibliographic study. Figure 14 illustrates the notable rise in discussions of this subject between 2018 and 2022, suggesting a growing interest in using cutting-edge algorithms to optimize energy systems. This trend emphasizes how crucial it is to include machine learning techniques to assist sustainable development in the renewable energy sector and improve efficiency and decision-making processes. The dots' increasing density over time demonstrates the growing scholarly attention paid to this technology-sustainability junction.

Conceptual Structure

A bibliographic analysis's conceptual structure involves tracing the links and themes within an area of study. Techniques such as Metric Multidimensional Scaling (MDS), Multiple Correspondence Analysis (MCA), and Correspondence Analysis (CA) are used to accomplish this (Ejaz et al., 2022b; Lourenço et al., 2023). By visualizing the relationships between authors, documents, and keywords, these techniques assist in highlighting the basic structure of the research domain. Clusters of similar concepts are frequently used in the visual representation to show the relationships between theme concentrations are highlighted with the specific color clusters, which show the links and linkages between these ideas. The graphics offer a thorough summary of the status of research on renewable energy selection and assist in finding key themes and trends.

In a bibliographic analysis, a thematic map shows how important themes are related and distributed throughout an area of study. Grouping subjects according to their density (development) and centrality (importance) makes it easier to spot specialized, developing, and well-established fields of study. This is a crucial tool for comprehending the composition and development of research fields. Terms like "data," "learning optimization algorithms," and "power system" are plotted across four quadrants of the map, as shown in Figure 16. The terms in the upper-right quadrant (renewable energy) are mature and central themes in the literature since they are both highly relevant and well-developed. Terms in the lower-left quadrant (machine learning, optimization), on the other hand, indicate developing or niche subjects since they are less established and less central. Researchers can identify important areas of emphasis and possible gaps in the discipline with the help of this graphic.

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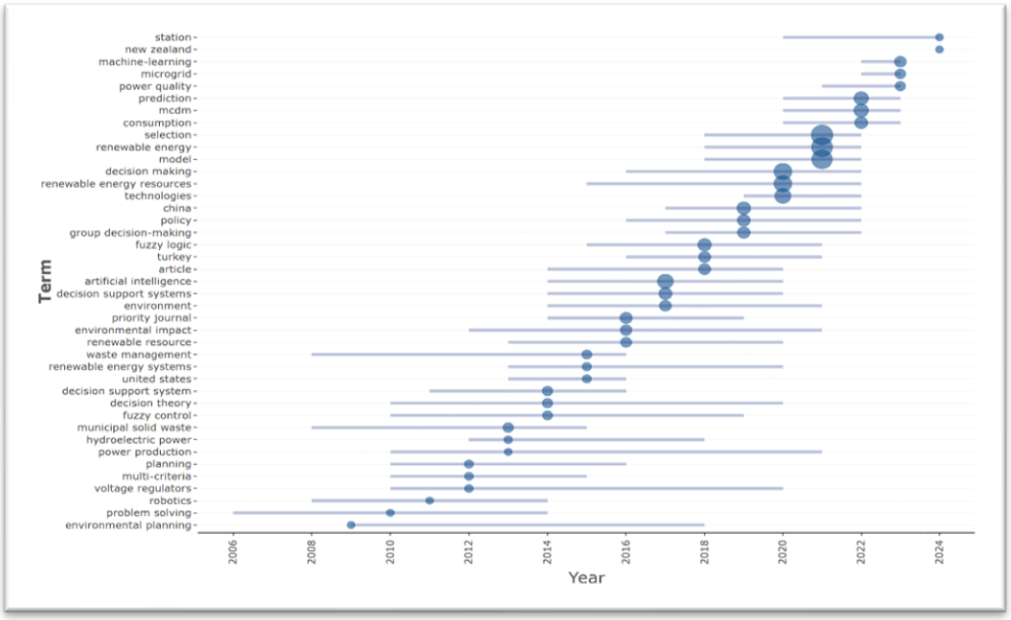

Figure 14. Trending Topic in RE Selection Research.

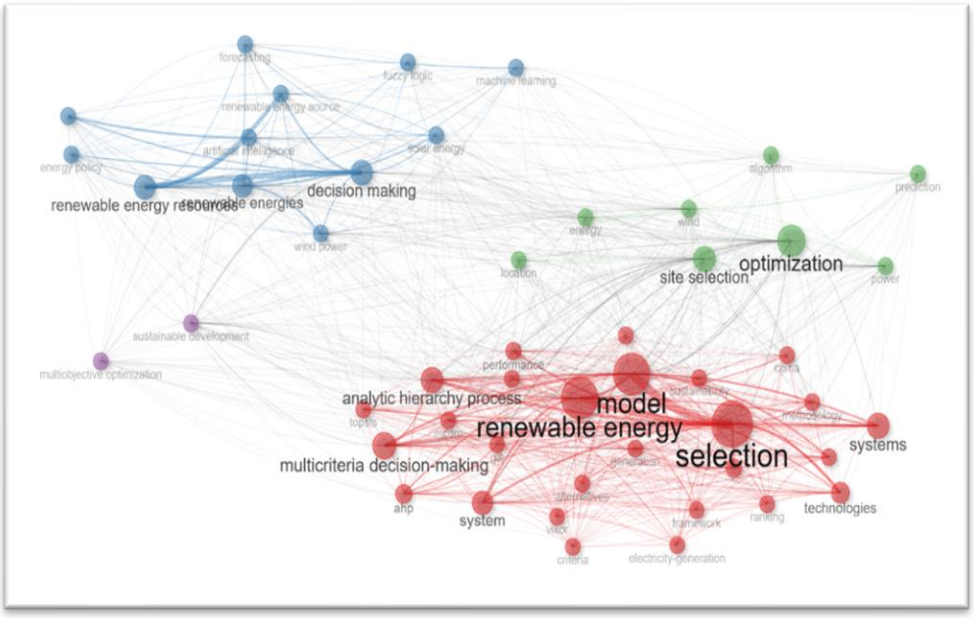

Figure 15. Co-occurrence Network Showing Mapping of Various Research Themes.

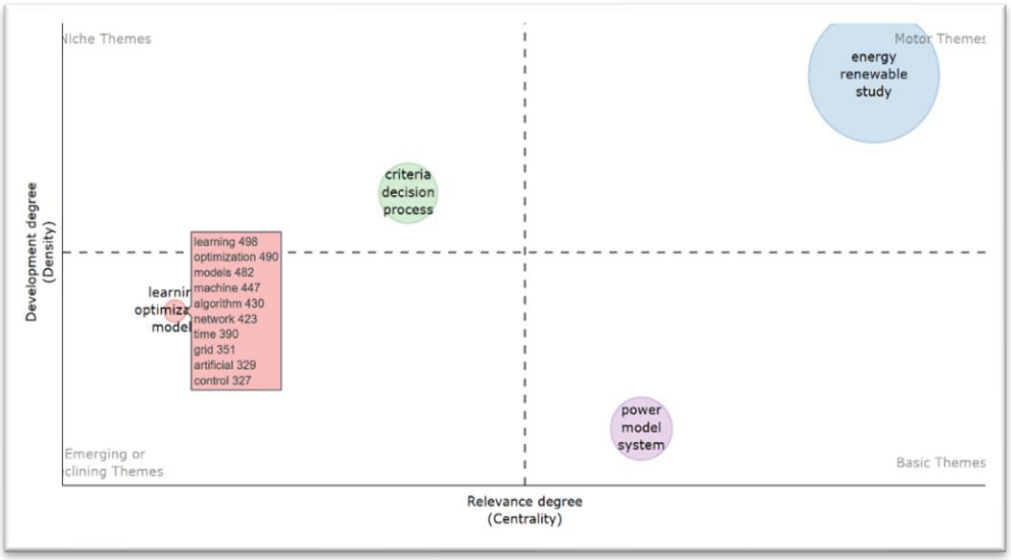

Figure 16. Thematic Map Showing the Various Terms used in the Research.

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The clustering of research articles about the preference for renewable energy is shown in the dendrogram (refer to Figure 17. The horizontal lines show the relationship between these studies with one another, and each vertical line indicates a single study. The studies are more similar, the closer the branches are to each other. We can observe clusters arising around important subjects like "wind power," "renewable energy resources," and "sustainable development" in this dendrogram. These clusters draw attention to the primary topics of study in the literature. Research on "renewable energy resources" and "sustainable development" are closely intertwined, signifying substantial academic attention in combining sustainability with renewable energy uses. This graphic helps simplify the rapid identification of key themes and connections within the topic of academics, directing future investigation and analysis.

integration of fuzzy logic and multi-criteria decision-making (MCDM) techniques, which are enhanced by machine learning and artificial intelligence. These methodologies align with SDG 7's goal of affordable and clean energy, highlighting innovative solutions and their real-world applications in optimizing energy selection processes. The bibliometric review of the various techniques associated with the prioritization or selection of renewable energy is carried out from 2000 to 2024, which shows a prominent increase in research collaboration and development. The scholar publishing annual growth rate of 22.56% points to how crucial and urgent it is to provide sustainable energy solutions. With almost 6,748 writers' contributions and an impressive worldwide co-authorship percentage of 24.84%, it is clear that the world is committed to improving renewable energy and its selection. The scrutiny of 2,766 research documents from Web of Science and Scopus recognized

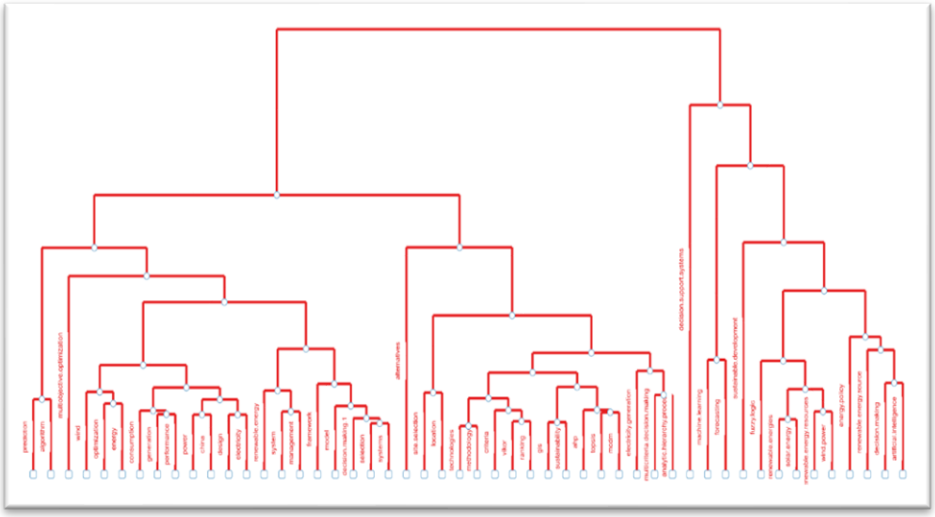

Figure 17. Dendrogram Showing the Relationship of the Renewable Energy Selection Studies.

Social Structure

Global research links in renewable energy selection are depicted in the collaboration map, Figure 18. The blue hues of the countries represent the amount of research output each country produces. Red lines show ties that facilitate collaboration between institutions or researchers in other nations. The dense network lines show the intense, concentrated cross-national cooperation in this subject. Large red lines denote robust international alliances, whereas nations with darker blue hues, like the USA and China, are probably significant research providers. The value of global collaboration in furthering research on renewable energy is shown in Figure 18.

Conclusion and Scope

This bibliometric study on renewable energy selection highlights key trends and advantages. It emphasizes the key researchers, journals, and trends, with China emerging as a leading nation in the field, with 511 papers published in 2023 compared to just 1 paper in 2000.

The most frequently employed keywords were "Selection," "Renewable Energy," and "Model," according to the main findings, with a frequency of 365, 334, and 312, respectively. This suggests the growing importance of machine learning and fuzzy MCDM in decision-making processes. Publications such as “Energies”, “Sustainability,” and “Renewable Energy” are the key sources for the research in this domain. Bradford's Law highlights the major significance and contribution of the sixteen important publications in Zone 1. The thematic and conceptual analysis demonstrated the clustering of important topics, such as ‘renewable energy’, ‘decision-making’, and ‘sustainable development’, the dominant research in this domain.

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China secures first position in the research contributions with 152 articles, followed by India (50) and Iran (39), with "North China Electric Power University" making a considerable contribution. significant studies from Wang JJ (2009) with 165 citations and Zadeh LA (1965) with 291 citations illustrate the significance of initial research in fuzzy-MCDM and renewable energy. With the help of keyword network analysis, 51 keywords were located and grouped into four clusters that showed the relationships between concepts like renewable energy, optimization techniques, and multi-criteria decision-making.

Figure 18. The Research Collaboration Network Across the World.

This study provides valuable insights into the evolution of renewable energy research and highlights the increasing role of fuzzy, multi-criteria decision-making techniques and machine learning. A study's analysis may contain inadequacies if it only uses these two databases, as it may remove relevant research from other sources. For a more comprehensive perspective, future research can consider more databases, which include grey literature. Nevertheless, the results provide valuable insights for promoting frameworks for decision-making and harmonizing renewable energy approaches with SDG 7.

Conflict of Interest

The authors declare no conflicts of interest.

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